questions are nontrivial and certainly need investigation. There are many aspects of bird migration other than orientation and navigation that need work. At present we know very little about the demographic and sexual features of bird migration, the importance of intraspecific and interspecific competition to the timing of migration and the seasonal distribution of the migrants, the relationship between migration and dispersal, the diverse patterns of plumage change among different species of migrants, and the relationship of bird migration to paleoclimatology and to past and current biogeography. These are important topics of investigation that must not be overlooked, for failure to make advancement in these areas will seriously jeopardize advancement in other areas that are currently receiving more than their fair share of attention.

Human Disturbance and Breeding Birds

DAVID C. DUFFY[1]

There is a growing concern about the effects of scientific investigation on breeding seabirds. For example, Nisbet (1978, Ibis 120: 134) has stated, "human disturbance by biologists is one of the major threats to seabirds," and Nelson (loc. cit.) was of the opinion that "contrary to what most people imply natural production rarely happens in populations that are studied by humans." Unfortunately, there are few studies in the literature to support or discount such pessimism.

The study by Ellison and Cleary of breeding Double-crested Cormorants (*Phalacrocorax auritus*) in the Gulf of St. Lawrence (1978, Auk 95: 510) is one of the very few attempts to see if the methods used in studying nesting success may themselves influence success. They found that "frequent visits caused nest abandonment, gull predation, and discouraged late-nesting birds from settling in disturbed experimental colonies." At one of their two study colonies, however, they found no significant differences in clutch or brood size between disturbed and undisturbed areas. In only one of four comparisons did they find a greater percentage of empty nests in the disturbed area. Even this finding may be questioned, as empty nests disappeared in a few days, the material being taken by neighbors. Because late nesters tended to settle in control plots, there may have been a greater demand for nesting material and, therefore, less chance that an empty nest would be present when Ellison and Cleary made their counts.

At their second colony, the activities of the investigators caused extensive desertions, which were attributed to inexperienced birds and to the proximity of a large gull colony. The only nests studied were those with eggs laid in late June or July. Palmer (1962, Handbook of North American birds, New Haven, Yale, p. 335) notes that nesting cormorants in Quebec generally have eggs present in May and early June. How representative of the species would a colony be if its breeding individuals were inexperienced, nesting late in the season, and "in sites not recently utilized by cormorants"?

The study of Ellison and Cleary is important, because it shows that observers had some effect on the nestings they studied. The type and extent of this effect are unresolved, but these are less important than the problem they raise for anyone undertaking similar studies.

I see two methodological difficulties of such studies of reproductive success and investigator disturbance. First, if one measures success using frequent visits to disturbed sites and less frequent visits to a control, there is the chance that, between visits to the control, nests may disappear altogether, and eggs or young that die may decay, wash away, or be scavenged. The less frequent the visits, the less evidence of mortality there may be and the higher the apparent productivity. Ellison and Cleary avoided this by using similar 1-day censuses for both experimental and control areas, but other studies have not (e.g. Gillett et al. 1975, Condor 77: 492; Robert and Ralph 1975, Condor 77: 495).

Second, there exists a paradox (or an "uncertainty principle"; Lenington 1979, Auk 96: 190) such that, if one disturbs birds while measuring their nesting success and if such disturbance lowers success, then the more "accurate" (=frequent) the measurement, the less real the productivity being measured. There

[1] Department of Biology, Princeton University, Princeton, New Jersey 08544 USA.

seem to be two ways around this: disturbance could be eliminated by making observations at a distance, or the "cost" of the method could be measured in controlled experiments, provided that an identical and independent measure of nesting success were used for both the experimental and control areas.

My major concern with this paper, however, is that it may be misinterpreted. Just because a study causes mortality does not mean that it necessarily has an effect on the population of the species being studied. Unless this is clearly pointed out, refuge managers and state and federal officials may quite understandably react to reports of scientist-induced mortality by restricting or denying access to colonies or species just when these are in need of careful and sympathetic study.

The Auk and other journals should routinely expect their authors to demonstrate the absence or at least the probable magnitude of investigator-induced mortality in productivity studies. Investigators unable or unwilling to do do this may find it more sensible to use methods for which the biases are already known (e.g. Tremblay and Ellison 1979, Auk 96: 364). An additional benefit of this might be greater standardization of methods of measuring reproductive success, which would allow more confidence in comparisons between different studies. *Received 27 March 1979, accepted 22 May 1979.*

Author's Response

LAURENCE N. ELLISON[1]

We welcome Duffy's valuable comments on our paper and on disturbance studies in general. Here we reply to three specific points before adding our own general comments. First, Duffy asks if the intense destruction of eggs and young documented on Île-aux-Pommes in a late-nesting (July) colony of Double-crested Cormorants (*Phalacrocorax auritus*) can be considered representative of the species? Probably not. Drent et al. (1964, Can. Field-Naturalist 78: 208–263) found, however, that human disturbance caused similar losses in July among Double-crested Cormorants who laid late clutches. In fact, these authors also reported that early visits in May induced such high predation losses that the investigators were finally forced to evaluate reproductive success by telescope from a blind.

Second, Duffy correctly cites our data showing no difference in mean clutch size or mean brood size in experimentals vs. controls on one island. These means, however, were based only on nests with eggs or young. Losses of total clutches or total broods were not considered. Thus the means are not necessarily a valid test for disturbance effects.

Third, Duffy notes that only one of four comparisons on Gros Pèlerin showed a greater percentage of empty nests in a disturbed site and that even for that comparison it is possible that late-nesters dismantled empty nests in the control. This criticism is justified. But even if one were to assume that each late-nesting couple dismantled an empty nest in the control, there would still be an excess of about 10% empty nests in the experimental on the ground in 1975 (Table 3). Moreover, there were more young outside their nests in the control than in the experimental in 1975, and these young were not allocated to any specific nests (footnotes, Table 3). This artificially increased the proportion of empty nests registered for the control. Thus we believe there is good evidence that nest failure was relatively high in the disturbed ground colony in 1975. We think it important also to recall that the disturbance effects recorded in the four experimentals corresponded with the intensity of disturbance and the susceptibility of the birds to disturbance. The two ground colonies were disturbed more than the two tree colonies. Eggs and young were not manipulated in the tree colonies and all adults were not forced from nests. Cormorants seemed more susceptible to disturbance in 1975 than in 1976. It is not surprising, therefore, that the ground colony in 1975 manifested two effects of disturbance, many empty nests and few late nests. The tree colony in 1975 also had few late nests. In 1976, the ground colony had few late nests, but no disturbance effects were noted in the tree colony.

We would like, however, to stress that 1975 may have been an exceptional year on Gros Pèlerin. A long-term study might reveal that Double-crested Cormorants on Gros Pèlerin are rarely as susceptible to disturbance as they were in 1975. Snow (1960, Ibis 102: 554–575) felt that her activities in a colony of Shags (*Phalacrocorax aristotelis*) induced a high predation rate on eggs in only 1 of 4 years when adults did not brood closely, perhaps because of food shortage.

[1] Dolgue, 34270 St. Mathieu, France.